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Growth and yield responses of soybean to direct incorporation of corn residues

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Abstract. The response of a soybean (*Glycine max* L.) cultivar Kaohsiung sel.10 to direct incorporation of corn (*Zea mays* L. cv. Tainung No.1) residues into the soil was studied in the summer crop of 1992 and the spring crop of 1993 on a silt loam at the experimental farm of Taiwan Agricultural Research Institute. The amount of plant residue was varied to three levels, 0 (control), x (full) and 2x (double). Significant increase of pod and seed yields occurred when double amount of plant residues was incorporated into the soil directly after ear removal in both crops. Double residues increased the seed yield relative to the control treatment by 13% in the Summer and by 12% in the Spring. Among yield components pod number and pod and seed weights were increased in the two growing seasons, while 100-seed weight was also increased in the summer crop. Incorporation of double amount of corn residues stimulated leaf number, leaf area, and plant weight yet decreased weeds collected from the soybean fields. When analyzing the changes of soil nutrient and moisture contents, it showed that, in general, corn residue treatments augmented more available potassium, total nitrogen and moisture in the soil during the growing seasons.

Key words: Soybean, Growth, Yield, Corn residue, Direct incorporation.

玉米殘留物直接混入土壤對大豆生長與產量之效應

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摘要：本項研究旨在探討直接混入前作玉米(*Zea mays* L. cv. Tainung No.1)植株殘留物於土壤中，對後作大豆(*Glycine max* L.)品種高雄選十號生長與產量之效應。田間試驗分別於1992年夏作及1993年春作在臺灣省農業試驗所農場進行，試區土壤質地為坋質壤土。混入土壤之玉米植株殘留

物量分為0（對照組）、x（全倍量）及2x（兩倍量）等三種處理，其中全倍量相當於每公頃 57100 株去穗後玉米植株殘留物。根據試驗結果，土壤混入兩倍量玉米植株殘留物明顯促進大豆莢與籽粒產量，夏作及春作分別增產籽粒13與12%。在產量構成要素中，每株莢數、莢重、及籽粒重均顯著增加，而百粒重在夏作亦上升。大豆生長性狀中，以葉片數、葉面積及植株乾物重之增加最為顯著。兩倍量玉米殘留物處理亦減少大豆田間雜草數量。進一步分析生長期間土壤營養元素及水分含量後，發現混入兩倍量玉米殘留物具有提高土壤中有效性鉀、全氮及水分之效果。

關鍵語：大豆、生長、產量、玉米植株殘留物、直接混入。

INTRODUCTION

Although crop residues are an important resource on the farm for animal feed and fuel, it is not uncommon to farmers in Taiwan to burn the plant residues left from the former crops. This action is taken to reduce the incidence of pest infestations in subsequent crops, yet products from the burning of plant residues cause serious air pollution and traffic problems. With advances in pesticides and technology to control diseases and pests, alternatives are needed providing methods for exploitation of these plant remains.

Unger (1986) pointed out that wheat residues can be managed to use a greater proportion of precipitation for producing subsequent corn crop. When rotated with corn, Bhowmik and Doll (1982) found that soybean yielded 10 to 15% better than grown continuously. Beatty and Eldridge (1980) reported that soybean yields were increased by rotation to grain sorghum for one year. In study a rotation of corn, sorghum, and soybean, Doran et al. (1984) showed that average grain yields of corn and soybean from the fields where crop residues were completely removed after harvest were lower than where residues were not removed.

In the previous report the chopped plant residues of corn after ear removal were found to affect the growth and yield of the subsequent soybean crops when incorporated into the soil (Yang et al. 1993). Seed yields of soybean Nung-Yu No.7 were significantly increased, ranged from 50 to 79%, by the incorporation of corn residues in the summer crop. It is yet to be known whether growth and yield of soybean would also be stimulated by the direct incorporation of corn residues rather than an indirect way. Such information is crucial for the adoption of this management practice since the return of chopped residues onto soil surface and then plow into soil profile is not practical in routine cultivations and adds an extra cost. Thus, a quantitative assessment of the effects of residue managements on soil properties and the resulting influence on the growth and yield of the subsequent crop is required and would considerably improve practices of these alternatives.

Objectives of this study were to evaluate the response of soybean to direct incorporation of plant residues left from the former corn crops into the soil and the differences of soil nutrient and moisture contents during the growing seasons.

MATERIALS AND METHODS

The present study was conducted at the experimental farm of Taiwan Agricultural Research Institute (TARI) at Wufeng, Taichung, on a silt loam (mixed, nonacid, hyperthermic, Fluvaquentic Dystrochrept), contained 26.5% sand, 51.1% silt and 22.4% clay. The pH and soil nutrient and organic matter (OM) contents, measured at the beginning of the growing seasons, in the top 0.25 m layer of this soil profile were listed in Table 1. Soybean cultivar Kaohsiung sel.10 was obtained from Soybean Research Laboratory of TARI and corn hybrid Tainung No.1 was purchased from Taiwan Seed Service (Ta-nan village, Shinshieh, Taichung Hsien).

Corn crops, the residue source, were planted at a rate of 57,100 plants ha^{-1} (full amount, x) and plant residues of aboveground dry matter remaining were directly plowed into the soil after ear removal with a rotary on 21 June 1992 and 27 November 1992. The soils were plowed again one week before planting. The amount of plant residue was varied to three levels, 0 (control), x (full) and 2x (double). Separate plots were selected for not cropping corn in at least a year prior to the experiments. The 8-row plots were 4.5-m wide and 10-m long with 0.55-m row spacings and soybean seeds were planted at a rate of 25 seeds m^{-1} on Aug. 4, 1992 and Jan. 28, 1993. The meteorological data, irradiance, daily mean temperature and rainfall, were collected from the weather station at TARI experimental farm.

The experimental area was fertilized with Taifei-39 fertilizer (N:P:K = 12:18:12) at a rate of 400 kg ha^{-1} two weeks after planting and sprayed with 1-Naphthyl-N-methyl-carbamate (50% WP, 2.5 kg ha^{-1}) and Mn^{2+} 16%/Zn^{2+} 2%/Ethylene-bisdithiocarbamate ion 62% (80% WP, 2.5 kg ha^{-1}) for pest control at flowering and between R6-R7, respectively.

The differences of soil pH, organic matter (OM), available phosphorus, available potassium, total nitrogen and moisture content (%, w/w) were monitored periodically during the growing seasons. The methods used for OM and nutrient contents analyses were the same as that described by Yang et al. (1993). Selected growth characteristics of soybean were meamsured on Oct. 13, 1992 and May 11, 1993 (at about R2 stage), separately. Stem height was measured from the soil surface to the top of plant stem with a ruler, leaf area was determined using an area meter (LI-3000, Li-Cor, Inc., Nebraska, USA) and plant dry weight was weighed after oven-dired at 80°C for 72h. A square meter of weeds was collected periodically and weighed after oven-dried. The central two rows of soybeans were hand-harvested for the estimation of yields on Nov. 12, 1992 and June 13, 1993, respectively, and additional 10 plants were harvested from the near rows to determine the yield components, including pod number, pod and seed weights (40°C for 96h), seed number and 100-seed weight.

Table 1. The pH and soil nutrient and organic matter (OM) contents of the soil measured at the beginning of the growing seasons.

Crop season	pH	OM	Available P	Available K	Total N
		%	ppm		
Summer 1992	4.7	1.88	21.3	96.6	1235
Spring 1993	4.6	1.88	23.6	99.5	1249

Experimental design was a randomized complete block with four replications. Analysis of variance, Least Significant Difference test were used for statistics. The standard errors were calculated for weeds comparisons.

RESULTS AND DISCUSSION

Weather conditions during the growing seasons of the summer crop of 1992 and the spring crop of 1993 were listed in Table 2. The distribution patterns and the accumulated values of irradiance, daily mean temperature and rainfall were varied between two seasons. These differences affected the decomposition of corn residues as well as growth of soybean and weeds.

It was shown that pod and seed yields were significanly increased when double amount of plant residues (aboveground dry matter remaining after harvest) incorporated into the soil directly after ear reomval of the former corn crops in both seasons (Table 3). A 13 and 12% increase of seed yields was recorded in the Summer and the Spring, respectively. By analyzing yield omponents, it indicated that increase of yield was due mainly to the increase of pod number and pod and seed weights, while 100-seed weight was found elevated in the summer crop (Table 4). Growth of soybean was also stimulated by corn residues. Among the selected growth characteristics, leaf number, leaf area and plant weight were singificantly increased (Table 5). On the other hand, less weeds were collected from soybean fields treated with double corn residues (Table 6) that may reduce weeds competition for growth requirements (Glauninger and Holzner 1982, Smith et al. 1977).

These results were similar to the previous experiment where corn residues were chopped to pieces before returning and plowing into the soil (Yang et al. 1993). With different

Table 2. Weather conditions during the growing seasons of Summer 1992 and Spring 1993 collected from the weather station at Taiwan Agricultural Research Institute Experimental Farm

Crop season	Time period	Accumulated irradiance	Accumulated daily mean temperature	Accumlated rainfall
		MJ/m^2	°C	mm
Summer	1992			
	Aug. 4-31	379.33	748.7	510.5
	Sept. 1-30	360-21	806-8	168.5
	Oct. 1-31	390.07	702.4	0.0
	Nov. 1-12	135.61	235.3	0.0
Total		1265.22	2093.2	847.5
Spring	1993			
	Jan. 28-31	56.45	45.3	0.0
	Feb. 1-28	334.54	495.1	1.0
	March 1-31	321.77	593.0	121.5
	April 1-30	337.63	661.2	116.5
	May 1-31	454.27	768.4	382.5
	June 1-13	114.49	332.9	296.5
Total		1619.15	2913.9	918.0

Table 3. Effects of direct incorporation of corn residues into the soil on yields of soybean, Kaohsiung sel.10, in the two growing seasons

Crop season	Treatment	Yield		Index
		Pod	Seed	
		--- ton/ha ---		%
Summer 1992	0 (ck)	2.990	1.674	100
	x	3.060	1.719	103
	2x	3.304	1.888	113
LSD (0.05)		0.298	0.168	
Spring 1993	0 (ck)	2.810	1.487	100
	x	2.873	1.563	105
	2x	3.045	1.671	112
LSD (0.05)		0.232	0.132	

Table 4. Effects of direct incorporation of corn residues into the soil on yield components of soybean, Kaohsiung sel.10, in the two growing seasons

Crop season	Treatment	Pod no.	Dry weight		Seed no.	100-seed weight
			Pod	Seed		
		no./plant	----g/plant----		no./plant	g
Summer 1992	2 (ck)	30.9	15.96	10.47	57.5	18.21
	x	33.0	16.82	11.20	59.3	18.85
	2x	33.9	17.42	11.72	60.5	19.38
LSD (0.05)		2.6	1.30	1.09	3.5	1.03
Spring 1993	0 (ck)	27.4	17.58	9.32	58.5	15.95
	x	27.3	18.47	10.03	62.8	16.00
	2x	31.3	22.15	12.16	70.0	17.20
LSD (0.05)		3.8	2.05	1.51	11.3	1.68

Table 5. Effects of direct incorporation of corn residues into the soil on the selected growth characteristics of soybean, Kaohsiung sel.10, measured on Oct. 13, 1992 and May 11, 1993

Crop season	Treatment	Stem height	Leaf no.	Leaf area	Nodule no.	Plant weight
		cm	no./plant	cm/plant	no./plant	g/plant
Summer 1992	0 (ck)	50.9	65.0	720.3	19.7	13.15
	x	521	71.9	711.4	17.3	13.61
	2x	51.5	78.8	833.3	18.8	14.77
LSD (0.05)		4.9	5.1	77.8	2.1	0.67
Spring 1993	0 (ck)	63.8	55.9	1516.8	16.4	17.00
	x	59.3	55.0	1438.1	15.3	16.78
	2x	59.5	64.3	2195.8	15.3	22.15
LSD (0.05)		7.1	8.4	557.8	3.3	4.55

Table 6. Effects of direct incorporation of corn residues into the soil on the amounts of weeds collected from soybean fields in the two growing seasons

Crop season	Sampling date	Treatment	Dry weight of weeds
			g/m^2
Summer 1992 @	Aug.25	0 (ck)	51.40 ± 2.77
		x	47.97 ± 2.89
		2x	44.11 ± 2.83
	Sept.24	0 (ck)	146.29 ± 14.45
		x	113.39 ± 25.26
		2x	107.65 ± 23.90
	Oct.17	0 (ck)	162.61 ± 14.94
		x	67.67 ± 19.34
		2x	119.56 ± 11.72
Spring 1993 @ @	Feb.18	0 (ck)	14.08 ± 1.43
		x	13.22 ± 1.45
		2x	12.08 ± 1.08
	April 16	0 (ck)	31.72 ± 2.19
		x	29.07 ± 2.16
		2x	26.93 ± 2.64
	May 18	0 (ck)	23.18 ± 1.83
		x	21.53 ± 2.52
		2x	18.50 ± 2.20

@: no weeding applied during the growing season.
@@: weeding applied on Feb. 19 and April 17 by handweeding and hoeing.

variety, Kaohsiung sel.10 instead of Nung-Yu No.7, however, this study found that seed yield was increased in not only summer crop but spring crop. Doran et al. (1984) showed that yield of soybean was 24% lower than where the former wheat residues were not removed. Nevertheless, additional field tests are needed to validate the effectiveness of corn residues on other soils and varieties and the contribution of environmental variations to soybean growth and the decomposition of buried residues.

In general, results showed that soils with corn residues incorporation stored more water during the growth period of soybean (Figs. 1 and 2), significantly different from 25 to 70 days after planting between double residues and the check. In other words, plant residues may provide conditions for using growing season precipitation more efficiently (Unger 1984, 1986), and hence further reduce the irrigation requirement for soybean. Corn residues also significantly increased the available potassium and total nitrogen measured in the soil since one week after planting (Figs. 1 and 2). As soybean growth and yield was enhanced by double amount of residues, it appeared that soybean were benefited from the improvement of soil moisture and nutrients availability. Further, the incorporated residues decompose over time to produce humic substances and orgainc matter may ameliorate soil physical properties (Emmerson and Dettmann 1959, Taylor and Henderson 1959, Yuan and Zhao 1981, Kemper and Kkoch 1966).

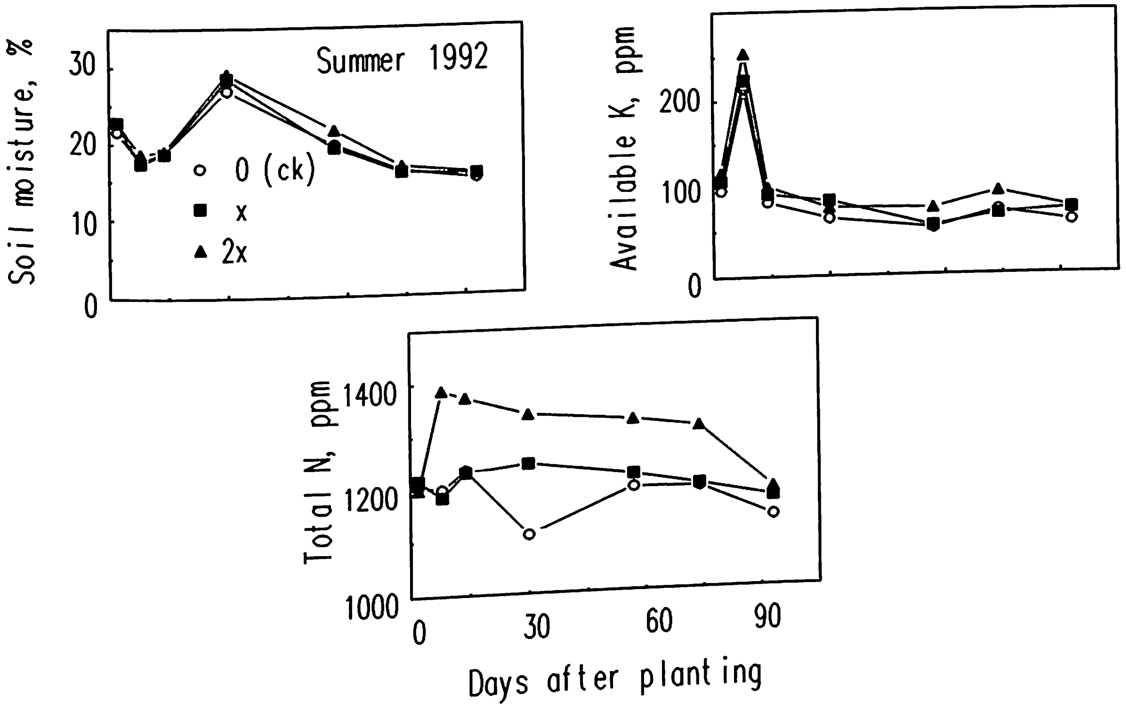

Fig. 1. Changes of soil moisture content, available potassium and total nitrogen as affected by the direct incorporation of corn residues into the soil during the summer crop of 1992.

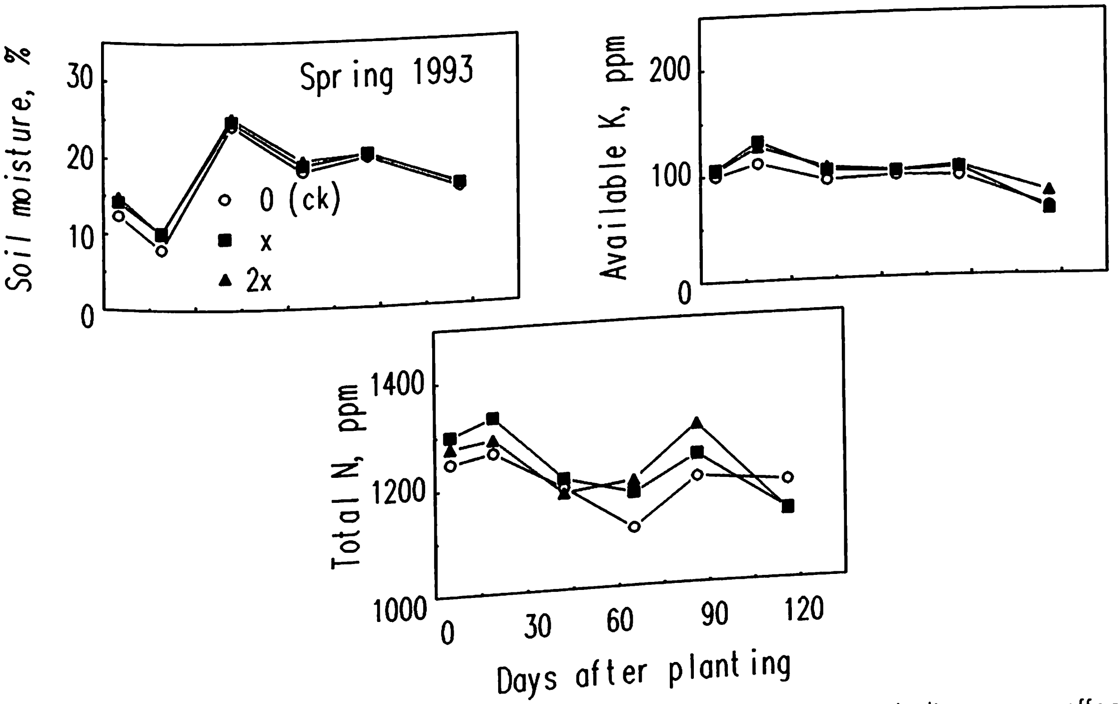

Fig. 2. Changes of soil moisture content, available potassium and total nitrogen as affected by the direct incorporation of corn residues into the soil during the spring crop of 1993.

Along with the results from the previous experiment (Yang et al. 1993), it suggested that effect of corn residues on soil productivity to soybean production is positive, especially at the double amount of residuces. From a yield standpoint, direct incorporation of corn residues before soybean planting is a superior practice to removing the residues from the field.

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